PPHB
ENERGY INVESTMENT BANKING

MUSINGS FROM THE OIL PATCH

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Note: *Musings from the Oil Patch reflects an eclectic collection of stories and analyses dealing with issues and developments within the energy industry that I feel have potentially significant implications for executives operating and planning for the future. The newsletter is published every two weeks, but periodically events and travel may alter that schedule. As always, I welcome your comments and observations.* Allen Brooks

What To Make Of Shell's Sky Planning Scenario?

Sky is Shell's effort to envision a possible pathway to a fully decarbonized global economy

Last month, Royal Dutch Shell (RDS.A-NYSE) introduced its newest planning scenario, Sky, to supplement earlier scenarios developed under its New Lens focus introduced in 2013. Sky is Shell's effort to envision a possible pathway to a fully decarbonized global economy. The scenario represents the changes required to achieve the goal of the 2015 Paris Agreement of keeping global temperatures from rising by more than 2° Celsius by 2100.

These two scenarios have dramatically different implications for society and the world's energy business

The New Lens effort resulted in two scenarios for how the 21st century could unfold - Mountains and Oceans. These two scenarios have dramatically different implications for society and the world's energy business. The scenarios involved taking key global trends and issues and their trajectory into the future to assess the pace of global economic development, the types of energy that will power economies and the growth in greenhouse gas emissions. The scenarios highlighted areas of public policy that might have the greatest influence on the development of cleaner fuels, improvements in energy efficiency and on reducing greenhouse gas emissions.

A 2013 article in the *Harvard Business Review*, based on the research for a book on the history of scenario planning at Shell, written by a 10-year veteran of the scenario planning group and another senior Shell executive, reviewed the 45-year history of the effort. While exploring why and how scenario planning began and evolved over the years, the authors developed a list of key principles for executing scenarios. The list, and brief key points, included the following:

- Make It Plausible, Not Probable
  You can never identify all the forces at play, and if you could, then predicting the future would be simple; so, scenarios need to be realistic

- Strike a Balance Between Relevant and Challenging
  Successful scenarios are derived from detailed consideration of the dilemmas and needs executives are confronting

- Tell Stories That Are Memorable Yet Disposable
  The narrative helps to manipulate people into being open-minded

- Add Numbers to Narrative
  For the oil business, the dominance of engineers in the executive ranks means that if you can't quantify what you are talking about, they will tend to dismiss it

- Scenarios Open Doors
  The process of developing the scenario gives insights into the way executives are thinking that you likely won't get otherwise

- Manage Disagreement as an Asset
  The value of scenarios is that they create a culture where when you ask a question, the answer needs to be within the context of the scenario

- Fit into a Broader Strategic Management System
  Scenarios provide the right framework for appreciating fundamental long-term choices, and not the same as next year's budget

The company's recent investments may further highlight its embrace of the Sky scenario

The opportunities and challenges in assembling long-term scenarios, as outlined above, provide executives with the ability to "think outside of the box" in assessing capital investment projects. One could point to Shell's purchase of BG Group, which significantly reoriented the company's fossil fuel portfolio in favor of natural gas. The company's recent investments may further highlight its embrace of the Sky scenario.

This venture into the retail power market may be a bet by Shell on increased gas demand from charging electric vehicles at home

Last December, Shell agreed to acquire British power provider First Utility, which will offer an outlet for Shell's gas supplies via the retail power market. This venture into the retail power market may be a bet by Shell on increased gas demand from charging electric vehicles at home. In the fourth quarter of 2017, Shell also invested in two projects to develop electric vehicle charging stations across Europe. Shell has also recently ventured back into the solar power arena following a 12-year hiatus by buying 44% of Silicon Ranch

It is estimated that the total of these investments is about $400 million

Corporation. This investment augments earlier Shell's agreements to buy solar power in Britain and to develop renewables power grids in Asia and Africa. It is estimated that the total of these investments is about $400 million, a significant amount. However, that spending is about 1.5% of the company's capital investments in 2017.

All Shell planners and executives strive to make sure Shell does not suffer the same fate as the dodo

While the amount of money Shell is devoting to renewables is relatively small, the decision to sell its oil sands holdings last year for $7.25 billion may be a more significant statement about the company's business strategy shift. This is where Shell's use of scenario planning, and especially the emergence of the new Sky scenario may be having a profound impact. That impact is explained by a framed plaque in the office of the head of Shell's planning scenarios. The plaque contains a drawing of a dodo, a bird discovered by Dutch sailors on the island of Mauritius in the 17th century. As the dodo's habitat was destroyed, the bird died out. The plaque warns that the dodo was "a once powerful bird," but it was hit with a change in its environment and "was unable to respond." The result is "the dodo is now EXTINCT." All Shell planners and executives strive to make sure Shell does not suffer the same fate as the dodo.

In an interview with *Fortune* magazine in January, Shell CEO Ben van Beurden highlighted the dilemma – the need to adapt – confronting Shell and the rest of the oil and gas industry. As he pointed out, in the past, "there was a funnel of outcomes that we had to navigate in, where a conservative approach could still work." He went on to say, "What is a challenge at the moment is that we don't know anymore where the future will go." This is why having additional planning scenarios that envision a very different world energy system becomes important for energy company executives.

Neither of these scenarios reflects the monumental goal achieved by the Paris Agreement

Shell's two planning scenarios under the New Lens initiative have been the subject of study and debate for nearly half a decade. However, neither of these scenarios reflects the monumental goal achieved by the Paris Agreement, in which 192 countries agreed to aggressively work to moderate, and even reduce, carbon emissions. Envisioning what it might take to make this effort work is what underlies Shell's Sky scenario.

The Mountains scenario anticipates a world with moderate economic development, in which government policies play an important role in shaping the global energy system and its environmental path

The Mountains scenario anticipates a world with moderate economic development, in which government policies play an important role in shaping the global energy system and its environmental path. These policies promote more compact cities and a transformed global transit system. Natural gas emerges as the backbone of the world's future energy system, with oil demand peaking in 2035. Electricity and hydrogen emerge as the dominant fuels of the global vehicle population by the end of the century. Carbon capture technology helps reduce CO_2 emissions from power plants to zero by 2060. While greenhouse gas emissions begin falling after 2030, they will still be too high to enable meeting the 2° C goal.

In the Oceans scenario, the world is more prosperous, but more volatile

In the Oceans scenario, the world is more prosperous, but more volatile. Public attitudes and market forces shape the global energy system, rather than government policies. Oil and coal remain significant energy fuels, as the use of nuclear power and natural gas are limited outside of North America due to public resistance and the slow adoption of policies to promote their increased use. Without popular support and policies, carbon capture and storage lags. This trend causes electricity generation to need over 30 additional years than in the Mountains scenario to reach carbon neutral. The surge in energy demand coupled with high oil prices enable the development of hard-to-reach oil resources, even though oil demand plateaus around 2040. These high energy prices encourage efficiency improvements as well as increased solar power. Solar power becomes the largest primary source of energy by the 2060s.

So, how different is the Sky scenario?

Shell planners outlined a scenario that differs materially from Mountains and Oceans scenarios signified by the following combination of mutually reinforcing drivers that are rapidly accelerated by society, markets and governments between now and 2070.

1. A change in consumer mindset means that people preferentially choose low-carbon, high-efficiency options to meet their energy service needs.

2. A step-change in the efficiency of energy use leads to gains above historical trends.

3. Carbon-pricing mechanisms are adopted by governments globally over the 2020s, leading to a meaningful cost of CO2 embedded within consumer goods and services.

4. The rate of electrification of final energy more than triples, with global electricity generation reaching a level nearly five times greater than today's level.

5. New energy sources grow up to fifty-fold, with primary energy from renewables eclipsing fossil fuels in the 2050s.

6. Some 10,000 large carbon capture and storage facilities are built, compared to fewer than 50 in operation in 2020.

7. Net-zero deforestation is achieved. In addition, an area the size of Brazil being reforested offers the possibility of limiting warming to 1.5°C, the ultimate ambition of the Paris Agreement.

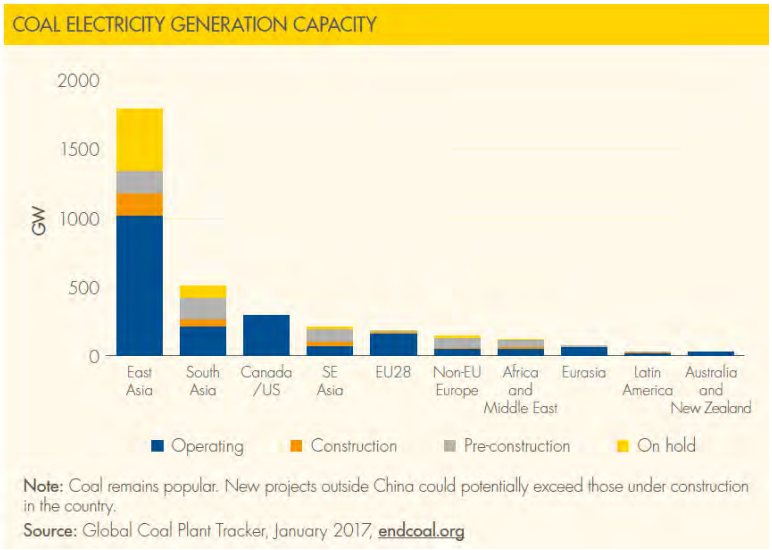
Despite these conditions, there remain a series of significant challenges for achieving a decarbonized economy by 2100. For

It was the increase in energy efficiency that contributed to economic growth during the 20th century as manufacturing costs and energy consumption of appliances declined steadily.

example, energy demand continues to rise because population growth continues and living standards increase. Additionally, increased energy efficiency can create unexpected consequences. As Shell points out, it was the increase in energy efficiency that contributed to economic growth during the 20th century as manufacturing costs and energy consumption of appliances declined steadily. Lower costs led to increased consumption by consumers, such as we are beginning to see with lighting as LED technology extends the life of bulbs and facilitates their use in commercial signs.

Another challenge is that coal remains an inexpensive and easy resource to tap and use, and it requires little technology to employ in generating electricity and heating. Importantly, coal is key to the smelting function critical for making iron. As Shell highlight, "A stark reality of the early 21st century is the lack of a clear development pathway for an emerging economy that doesn't include coal." That point is demonstrated in Exhibit 1 from the Sky scenario.

Exhibit 1. How Coal Use Complicates Scenario



Source: Shell

There are few apparent low-carbon solutions for aviation, shipping, cement manufacture, some chemical processes, smelting and glass manufacture

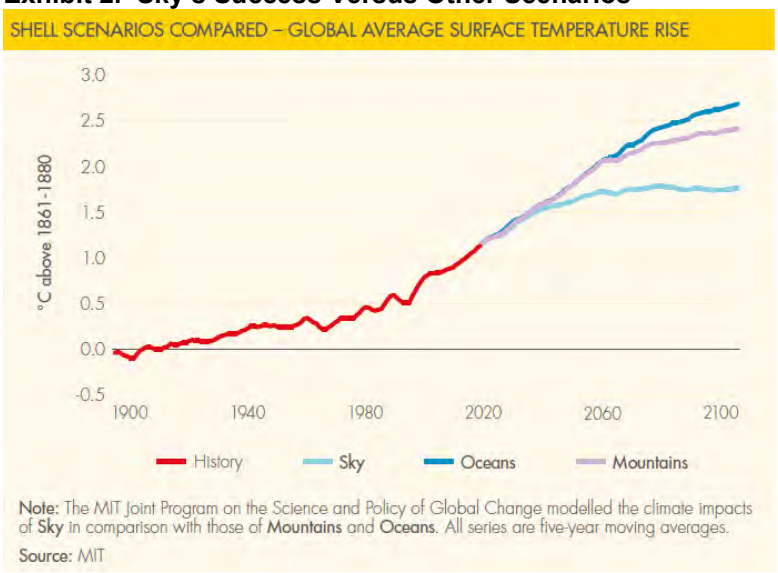
As Shell further offers, some parts of the energy system are "stubborn." In particular, there are few apparent low-carbon solutions for aviation, shipping, cement manufacture, some chemical processes, smelting and glass manufacture. This means significant sectors of modern industrial economies won't be able to transition rapidly to a zero emissions world. To some degree, this challenge is tied to the issue of various technologies being "stalled." Shell cites hydrogen for the transportation system as a technology that has been supplanted by developments in battery technology. Biofuel development has also stalled as a technology that could provide high-energy density, low-carbon footprint fuels for certain transportation markets.

Shell's final challenge that "given the time frame of 2070, there can be no slippage"

Potentially, one of the most difficult challenges is that energy system transformations are unpredictable and take time, which runs into Shell's final challenge that "given the time frame of 2070, there can be no slippage." Therein lies the greatest challenge for the Sky scenario – it requires a significant revamping of energy systems, which will need social and political support to enact, yet there is little time to make the necessary adjustments. Absent from Shell's Sky scenario is any commentary on the cost necessary to make the transition, let alone the economic damage that would be inflicted on society if new energy technologies do not follow the projected downward cost curves and timelines assumed.

Understanding the Sky scenario requires seeing how it would facilitate meeting the Paris Agreement global temperature goal in contrast with Shell's Mountains and Oceans scenarios. The difference is captured in Exhibit 2.

Exhibit 2. Sky's Success Versus Other Scenarios

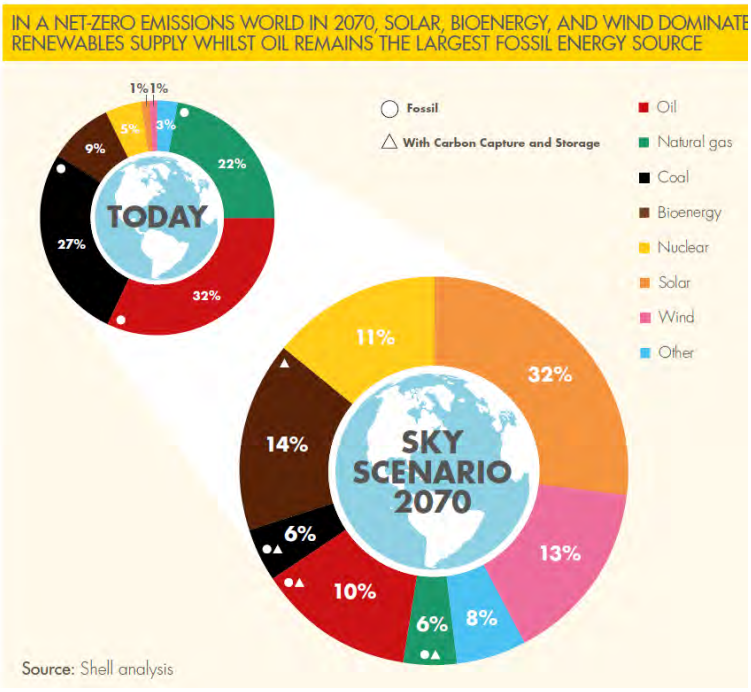


Source: Shell

One shows how in a net zero emissions world in 2070, renewables dominate the fuel supply, although oil remains the largest fossil fuel source

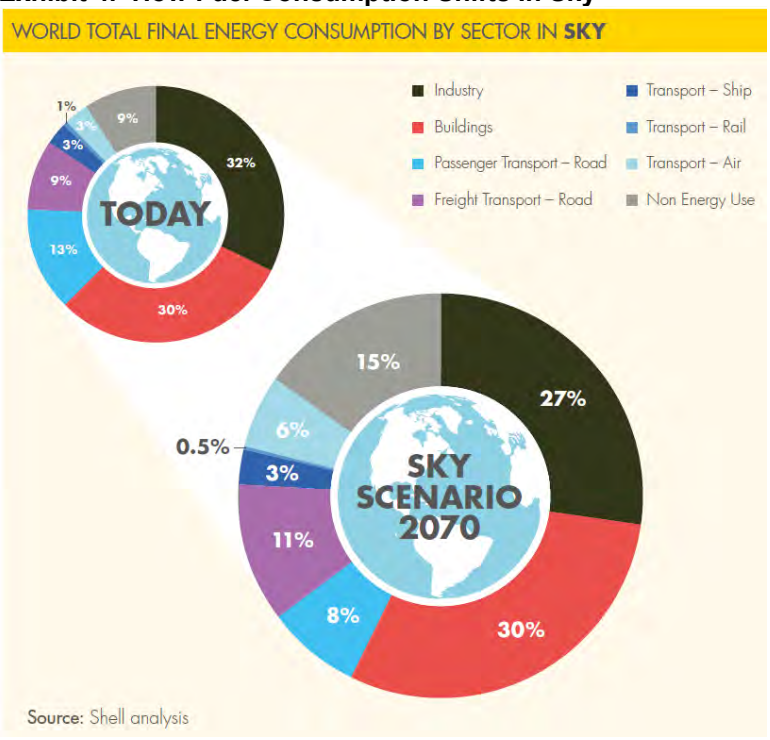
Two charts summarize Sky's conclusions. One shows how in a net zero emissions world in 2070, renewables dominate the fuel supply, although oil remains the largest fossil fuel source. The second chart shows how energy use by economic sector changes over time. Industrial energy use, as well as passenger road transportation, decline, while freight, air transport and non-energy use increase.

Exhibit 3. How Energy System Changes In Sky



Source: Shell

Exhibit 4. How Fuel Consumption Shifts In Sky

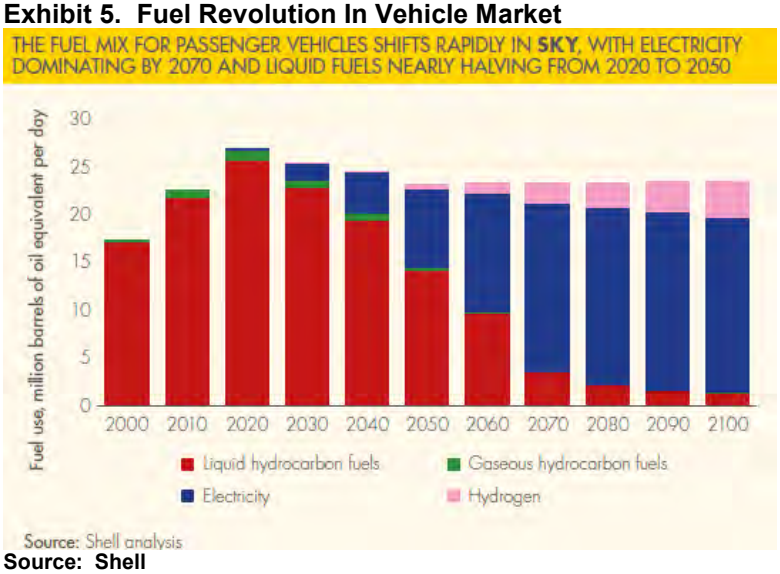


Source: Shell

Electricity for the vehicle fleet dominates by 2070

As this zero-emissions world evolves, there will be significant shifts in the use of fuels in various sectors. For example, electricity for the vehicle fleet dominates by 2070, as oil use begins falling after 2020.

Exhibit 5. Fuel Revolution In Vehicle Market

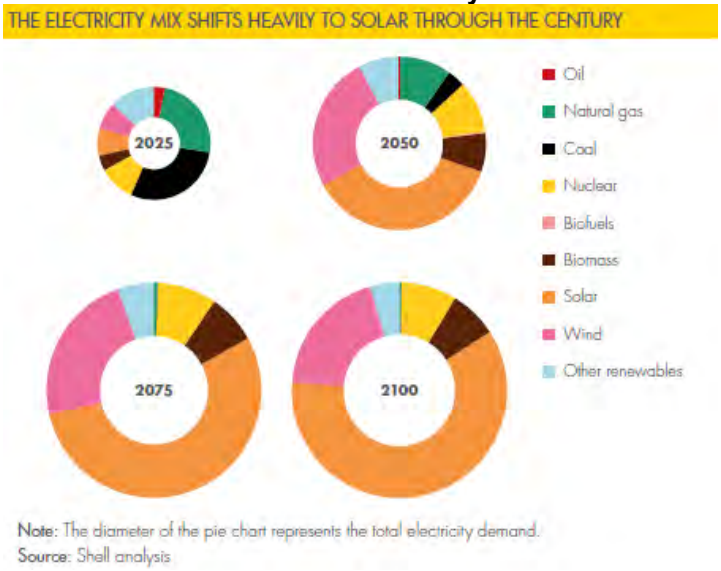


Source: Shell

The mix of fuels used in generating electricity is another area where significant change is observed

The mix of fuels used in generating electricity is another area where significant change is observed. While the amount of electricity used in the global energy system increases dramatically by the end of the century, all fossil fuel supplies are eliminated and largely replaced by wind, biofuels and solar. The latter energy source winds up dominating the electricity generation fuel supply by 2075.

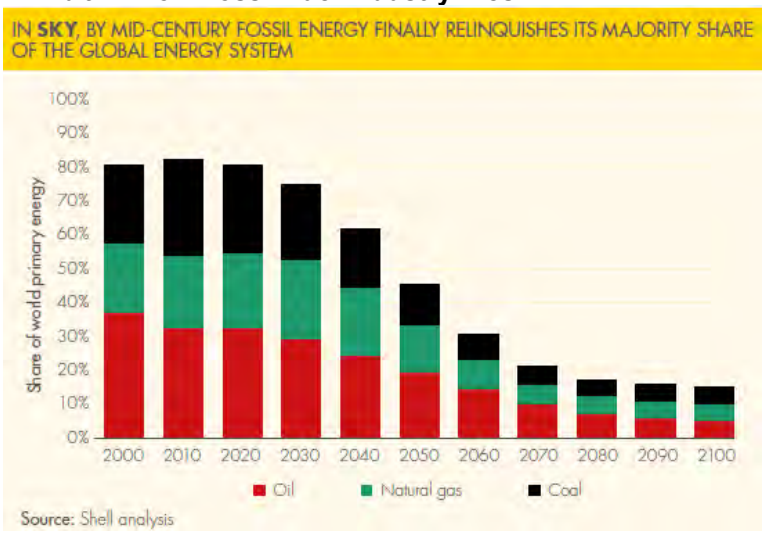
Exhibit 6. Solar Dominates Electricity Market



Source: Shell

The net result of these dramatic shifts in the fuel supply mix is that fossil fuels no longer supply over half of global energy.

Exhibit 7. How Fossil Fuel Industry Dies



Source: Shell

The Sky scenario suggests a radically different world, and one in which existing energy companies will need to make major structural changes to survive and compete. In several of the conclusions offered by the Sky scenario, analysts have wondered whether they were reached with Shell's strategy dictating a "thumb on the scale."

The problem with these conclusions is that Shell had developed a similar scenario in the early 1990s, which led to environmentalists embracing the company

On the other hand, some observers suggest that the great interest in the Sky scenario is a reflection of two conclusions. First, an important oil industry company expects this scenario to happen. Second, the scenario confirms that an important oil industry player acknowledges that a severe climate policy future is needed. The problem with these conclusions is that Shell had developed a similar scenario in the early 1990s, which led to environmentalists embracing the company. As energy expert Michael Lynch wrote, "The point is that, even if one considers forecasts to be predictions of the future, scenarios are most definitely not." He argued that one mistake planners often make is to take likely trends out of a forecast and put them into a scenario. For example, he points out how the Energy Information Administration (EIA) and the International Energy Agency (IEA) do not want to predict governments tightening emissions standards, but that is more likely in a "business-as-usual" forecast than to assume a static per-unit emissions measure.

Mr. Lynch suggests that the big difference between Sky and Shell's earlier green forecast is not the content but rather the increased probability that future policies will be tilted against fossil fuels. Therefore, he sees the true value in Sky to be the micro-level analysis of that policy rather than its existence.

Climate hawks are targeting Sky not because it is unambitious or notably easier on fossil fuels than other decarbonization plans, but rather that all climate modeling is designed to protect large energy incumbents from disruption

Another analysis of the Sky scenario involved comparing how it compares with other green forecasts. In essence, the climate hawks are targeting Sky not because it is unambitious or notably easier on fossil fuels than other decarbonization plans, but rather that all climate modeling is designed to protect large energy incumbents from disruption. The conventional climate model consensus is suggesting that what is required to get to the 2° C goal means continued emissions growth in the short term, then radical reductions and negative emissions in the long-term.

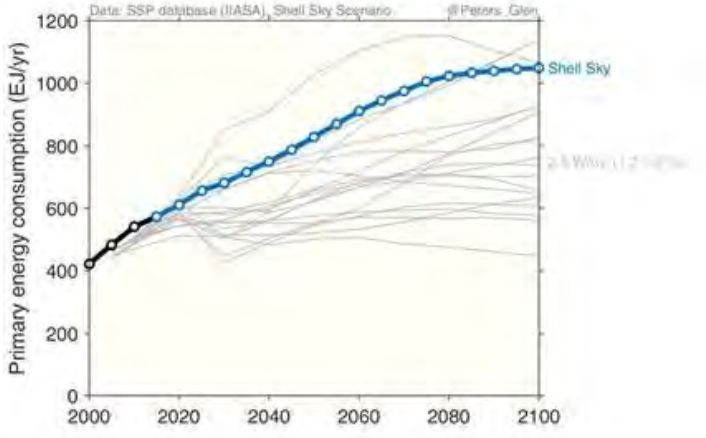
If a climate hawk is attacking Sky and other zero carbon emissions models for protecting energy companies, it is entirely possible that the climate modeling community is recognizing reality. That being that there is little in the way of policy changes that will slow carbon emissions growth for the foreseeable future. To get the radical reductions and negative carbon emissions embedded in the decarbonized forecasts will require not just policy changes, but the embrace of technologies that likely do not exist.

An article by *Vox* tapped the work of Glen Peters, research director at Norway's Center for International Climate Research, who prepared analyses of Sky and the scenarios that the Intergovernmental Panel on Climate Change (IPCC) uses now as the basis of its modeling (Shared Socioeconomic Pathways, "SSPs"). There are roughly 30 SSPs, which vary based on different sets of assumptions. So just how did Sky compare?

Shell's high fuel demand is a feature of virtually all its scenarios

With respect to global energy demand, Sky ranks toward the very top of the scale. Given Shell's belief that the world will experience rapidly rising living standards in the developing world, it is not surprising it sees more energy needed. While an official of *CarbonBrief* pointed out that Shell's high fuel demand is a feature of virtually all its scenarios, some are questioning whether the company is tipping the scales in favor of the energy industry.

Exhibit 8. Sky Has High Energy Usage

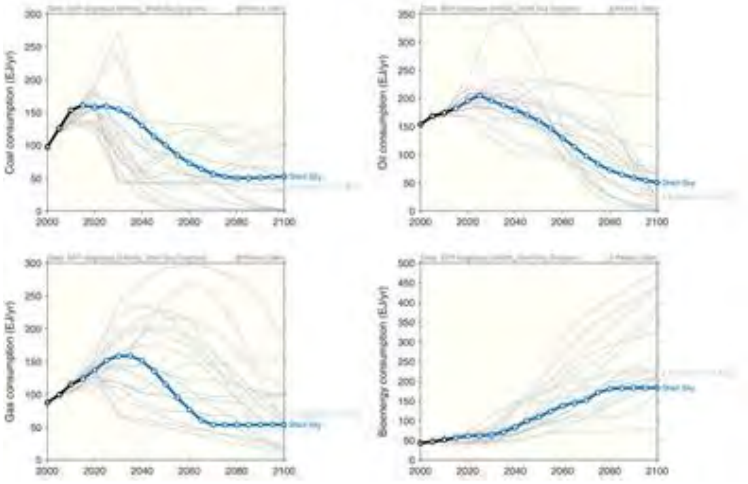


Source: Glen Peters

In regards to fossil fuels, Sky's forecasts fall well within the mainstream of the SSPs model forecasts

In regards to fossil fuels, Sky's forecasts fall well within the mainstream of the SSPs model forecasts. In fact, Sky's forecasts for coal and oil consumption were about in the middle of all the models, while its outlook for natural gas and biofuels tended to be below the 50% point.

Exhibit 9. Sky Doesn't Differ Much From IPCC

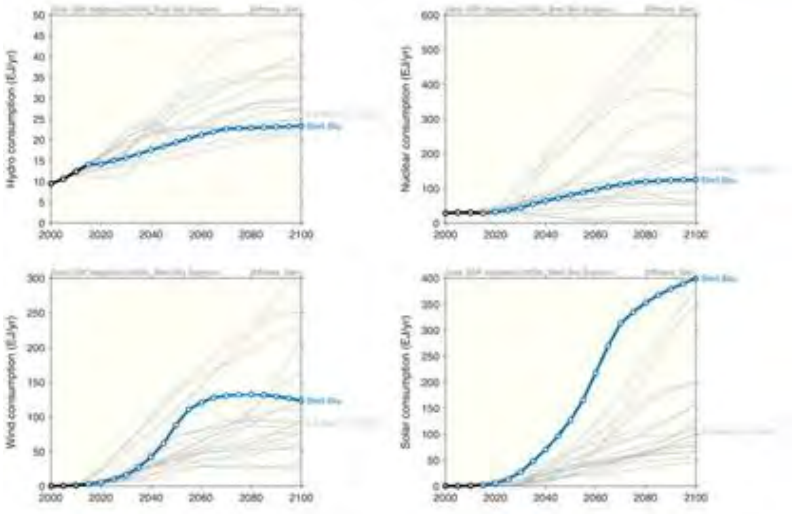


Source: Glen Peters

In the solar case, Shell's forecast is above all others by 2100

Where the Shell forecasts differ noticeably is in the consumption of solar and hydro. In the solar case, Shell's forecast is above all others by 2100. On the other hand, its view of hydro power projects a future toward the absolute bottom of the range of climate model forecasts. For wind and nuclear, while the Sky outlooks are within the range, they may be too low for nuclear and too high for wind.

Exhibit 10. Sky Likes Solar And Not Hydro



Source: Glen Peters

the Sky scenario, and virtually every other climate model targeting zero emissions, expects carbon emissions to keep rising in the near-term because it is impossible to turn the carbon-intensive energy system that powers today's global economy around on a dime

The most significant difference between Sky and the SSPs is their view on the success of carbon capture and storage. Although Shell is counting on the technology to help achieve the negative carbon emissions needed in the later years of its forecast, compared to the outlooks of the SSPs, Shell is highly conservative. This difference plays into the challenge of all climate models attempting to develop pathways to a zero-carbon-emissions world. As the *Vox* article puts it, the Sky scenario, and virtually every other climate model targeting zero emissions, expects carbon emissions to keep rising in the near-term because it is impossible to turn the carbon-intensive energy system that powers today's global economy around on a dime. Shell actually makes that point, when it writes: "From 2018 to around 2030, there is clear recognition that the potential for dramatic short-term change in the energy system is limited, given the installed base of capital."

The first bet is that carbon capture and sequestration technology, unproven at scale today, will work

The problem with Sky, and the other climate models, for climate hawks is the two implicit bets made in order to achieve the zero-emissions goal. The first bet is that carbon capture and sequestration technology, unproven at scale today, will work, and especially work for the magnitude of carbon needed to be withdrawn from the atmosphere to reach the 2° C goal. As climate modeler Christopher Clack of Vibrant Clean Energy noted, the volume of carbon Shell forecasts can be removed from the atmosphere every year from 2070, is equivalent to 1.7 times current total U.S. carbon emissions. That volume also represents the equivalent of one-third of total global emissions, today.

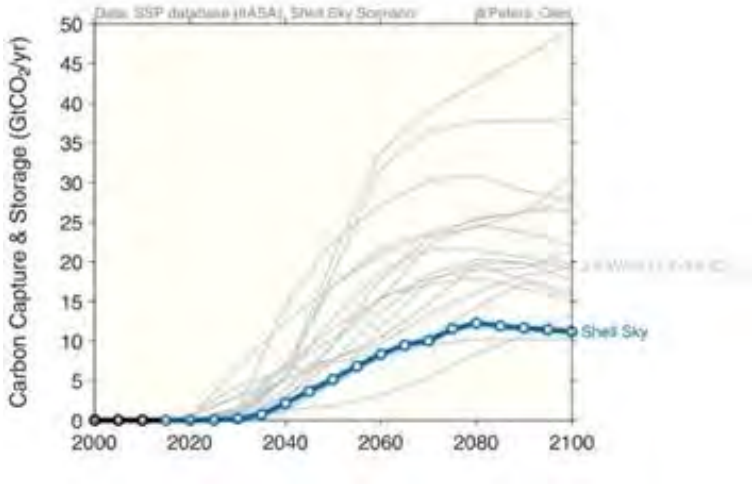
As significant as the Sky forecast suggests, Mr. Peters research shows that Shell's outlook for carbon capture and sequestration is in the bottom of the ranking of all the SSPs. Therefore, one has to assume that any criticism of the Sky projection would be doubly critical of other climate models. All of these forecasts highlight the significance of their dependence on carbon capture to meet their environmental targets. Does this suggest that Shell's Sky scenario, despite its dependence on carbon capture, is actually more realistic than the SSPs forecasts?

The second bet the climate hawks see is that these scenarios essentially yield odds for attaining the Paris Agreement target at about two-thirds

The second bet the climate hawks see is that these scenarios essentially yield odds for attaining the Paris Agreement target at about two-thirds. This flies in the face of what was actually agreed to by the participants at Paris. Each country agreed to develop a plan to limit, or reduce, carbon emissions so that a 2° C global temperature increase would be the ceiling. They also agreed to "pursue efforts" to limit the temperature increase to 1.5° C. If your odds of failing to reach the ceiling goal are 33%, then what are the chances of reaching the aspirational target countries are supposed to be striving to attain? They are little to none, unless the radical structural changes to the energy system are begun at least a decade earlier than outlined, or possibly even begin immediately. That latter option doesn't truly exist given the inability of most countries to

develop plans that meet the requirements for the less strict temperature increase scenario.

Exhibit 11. Everyone But Sky Like CCS



Source: Glen Peters

Sky has demonstrated the magnitude of the structural changes necessary to achieve the zero-carbon-emissions goal by 2075

What Shell's Sky scenario has done is fan the flames of the criticism of the oil industry's stonewalling acknowledgement of climate change and the role its product has played in boosting carbon emissions. At the same time, Sky has demonstrated the magnitude of the structural changes necessary to achieve the zero-carbon-emissions goal by 2075. Moreover, the entire exercise's success is predicated on certain technologies that are unproven at the scale necessary for them to be successful. Lastly, we have no way of knowing what this exercise will cost, let alone whether it will work. The value in scenario planning is that it helps isolate the critical decisions and technologies that must come together to achieve ambitious goals. If anything, it helps executives focus on the important decisions they must make, and what the outcomes from these decisions might look like. None of the decisions are easy, but having a possible path outlined helps increase the focus.

The Never-ending Winter Creates Challenges For Natural Gas

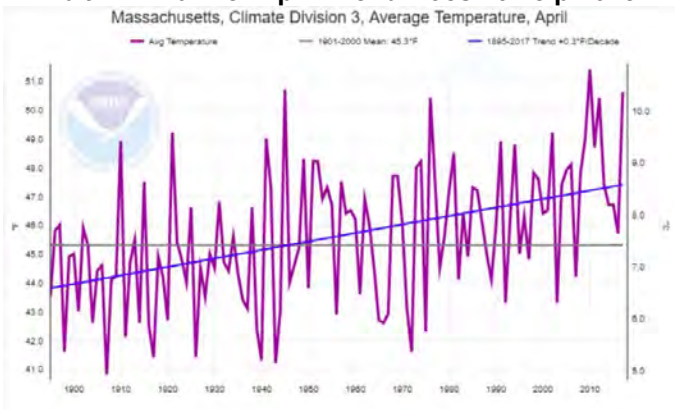
Last week, the opening day baseball game of the Chicago Cubs was postponed due to snow!

In the last *Musings,* we discussed the charge of fraud leveled against Punxsutawney Phil for predicting only six more weeks of winter, as he raced back into his burrow on Groundhog Day. Last week, the opening day baseball game of the Chicago Cubs was postponed due to snow! The potential for a huge snow storm in Washington, DC on April's first weekend required several climatic conditions to come together at the same time. When that coincidence failed, clouds and rain prevailed, thereby saving the cherry blossoms.

The European climate forecasting model has switched from its earlier view of more normal spring weather to now forecasting colder temperatures

What has happened weather-wise, however, is that April has suddenly become colder than normal. As pointed out by a Boston-based meteorologist, the European climate forecasting model has switched from its earlier view of more normal spring weather to now forecasting colder temperatures. This weatherman pointed out that since 1900, April temperatures in Boston have been in a warming trend. Such a trend, however, doesn't prevent individual years from being warmer or colder than the trendline would suggest. This April warming trend is consistent with the interglacial warming period that the planet is in.

Exhibit 12. Warmer April Trend Doesn't Help 2018

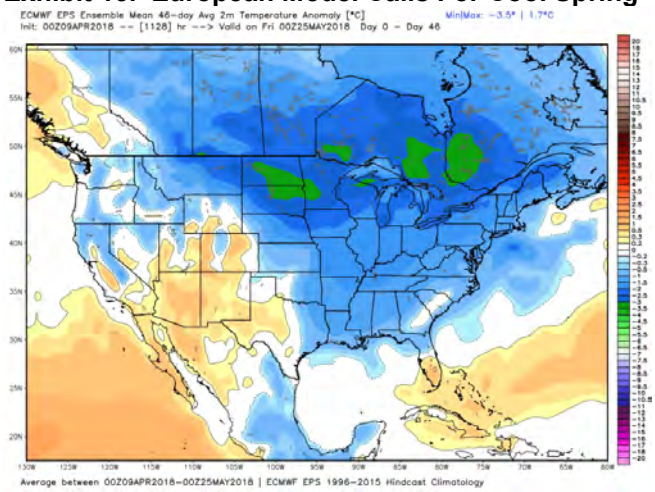


Source: ***Boston.com***

This development may prove helpful for the natural gas market

The latest European model is forecasting colder than normal temperatures in the northern tier of the country and for the eastern half of the country through Memorial Day at the end of May. This development may prove helpful for the natural gas market, which is always dependent on Mother Nature for its demand.

Exhibit 13. European Model Calls For Cool Spring

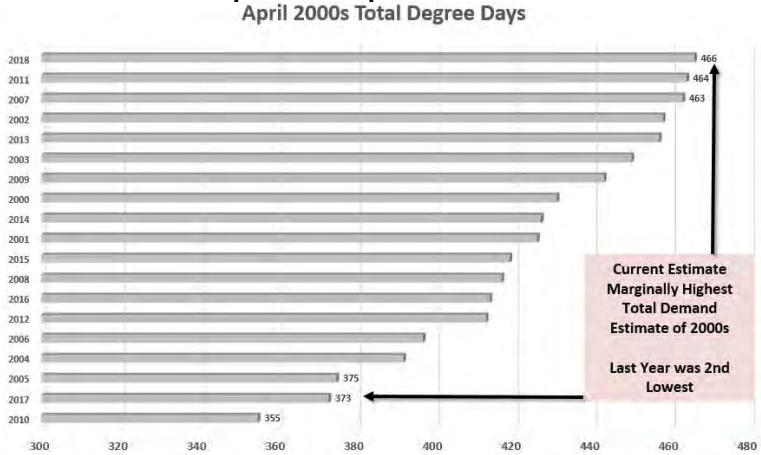


Source: ***Boston.com***

April 2018 might generate the highest total weather impact on natural gas

Commodity Weather Group LLP tracks the impact of weather on commodity markets. As March was ending, Commodity Wx projected that April 2018 might generate the highest total weather impact on natural gas. Their chart showed where 2018 ranked against all other April months in each year of the 2000s. They noted how April 2017 had the second lowest impact on gas demand.

Exhibit 14. This April Will Impact Natural Gas Market



Source: Commodity Wx

Just one day later the percentages increased again, and by significant amounts

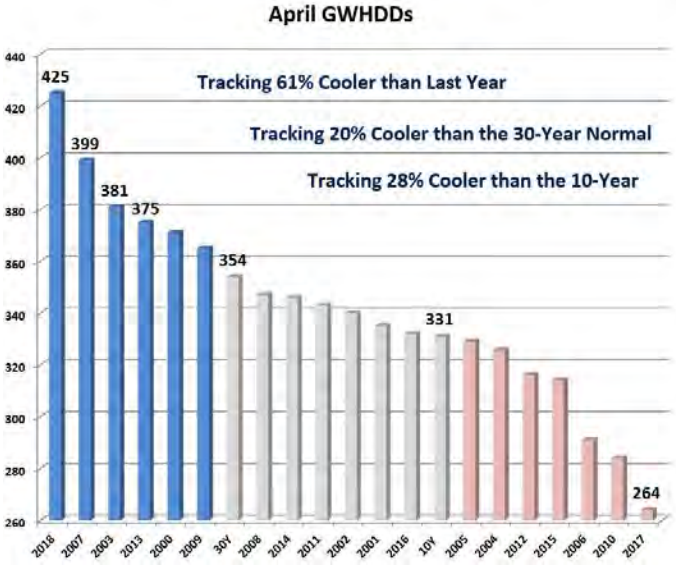
What we found interesting has been following the progression of upwardly revised estimates for gas weighted heating degree (GWHDD) days as we have traversed the early days of April. Exhibit 15 (next page) shows how April's actual and forecasted GWHDDs are tracking as of April 10. The chart the firm prepared on April 4 showed that the three trackings were 44%, 8% and 15% cooler, respectively, compared to last year, the 30-year normal and the 10-year normal. On April 9, those percentages had increased to 54%, 15% and 23%, respectively. Just one day later, the percentages increased again, and by significant amounts.

What does this mean for natural gas for the balance of 2018? So far, the April increase in GWHDDs hasn't had much of an impact on natural gas spot prices. The lack of gas price movement likely reflects the market's belief that adequate supply exists regardless of how strong demand becomes. That view is shaped by the continued growth in production, especially the supply coming from growing associated natural gas output coming from greater shale oil volumes from the Permian Basin.

Gas, measured by gross withdrawals and marketed production, reached record highs at the end of 2017

The Energy Information Administration (EIA) published a chart last week of the history of domestic natural gas production. The chart shows how gas, measured by gross withdrawals and marketed production, reached record highs at the end of 2017. Although dry natural gas production peaked in 2015, the 2017 volume wasn't far below that peak. The key takeaway from the chart is how

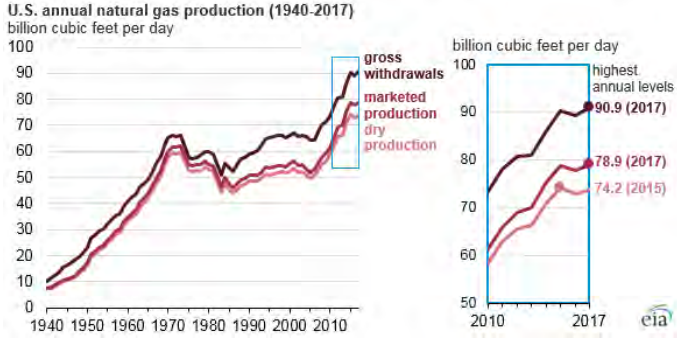
Exhibit 15. Latest Weather Shows Maximum Gas Demand



Source: Commodity Wx

dramatically domestic natural gas output has risen since the shale revolution emerged in 2007.

Exhibit 16. Gas Production Is Setting Historical Records



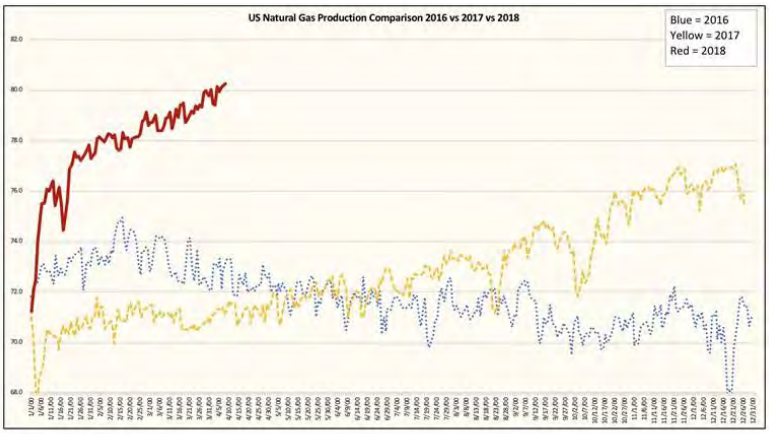
Source: EIA

The lack of gas pipeline capacity will force Permian producers to re-orient their work toward oil wells with little or no associated gas

Another chart of natural gas production for 2016, 2017 and year-to-date for 2018, shows how output has surged this year. Expectations are for supply to continue growing, although there is a possibility that gas pipeline capacity from the Permian Basin is reaching maximum capacity, which could limit further gas production in the near-term. In other words, the lack of gas pipeline capacity will force Permian producers to re-orient their work toward oil wells with little or no associated gas.

On the other hand, natural gas export capacity has expanded with the opening of the Cove Point, Maryland liquefied natural gas (LNG) terminal. Therefore, more supply may be committed to international markets, limiting U.S. available natural gas supply. Even though

Exhibit 17. 2018 Gas Production Soaring

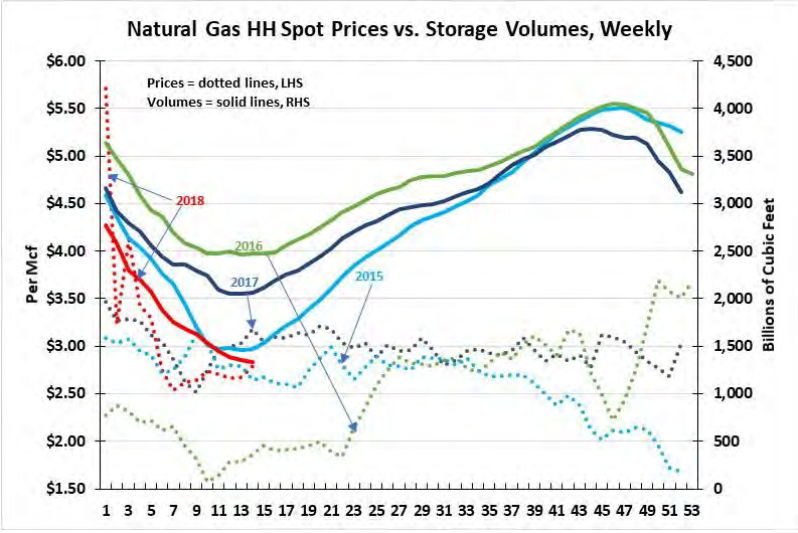


Source: ***Seeking Alpha***

We have suggested that the worst outcome for the domestic gas industry is for it to follow the pattern of 2015

there is no additional LNG export capacity coming on stream before 2019, the U.S. natural gas industry may find itself in a takeaway straight-jacket for the next 9-12 months. How will the need to rebuild gas storage this summer and, possibly more consumption due to hot weather, play out in the tone of the gas market for the second half of the year? At the moment it is having little impact, if we consider natural gas spot prices remaining stuck below $3 per thousand cubic feet as an indication. The gas pricing dilemma is highlighted in Exhibit 18, which shows monthly gas production for 2015-2018, as well as Henry Hub spot gas prices. We have suggested that the worst outcome for the domestic gas industry is for it to follow the pattern of 2015. Since we published this chart a few weeks ago, 2018 gas prices have continued to track the pattern of 2015 prices.

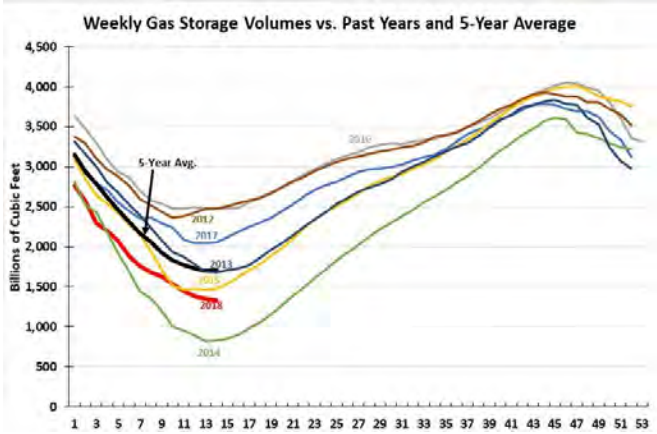
Exhibit 18. 2018 Gas Prices Following 2015 Pattern



Source: EIA, PPHB

Just how demanding will the natural gas storage market be?

Exhibit 19. Gas Storage Setting Up Market For Price Lift



Source: EIA, PPHB

The challenge is to figure out how the gas industry rebuilds storage

Gas storage has continued to fall since we published this chart several weeks ago. The gas storage figure as of the week ending March 30, 2018, had 2018 volumes about 100 billion cubic feet (Bcf) below 2015, but 500 Bcf above the worst year, which was 2014. Importantly, 2018 is roughly 300 Bcf below the 5-year average storage volume. The challenge is to figure out how the gas industry rebuilds storage to such a level that consumers, gas companies and regulators are not inordinately concerned about supply disruptions.

By estimating the gas volume injections needed this summer, we find a significant hurdle may exist

To understand this challenge, we examined the 5-year gas storage average volumes that were matched against each year from 2015-2018. This enabled us to see where the average weekly storage volume was for the last week in March as well as the last week in October – the span of the gas injection season. We were then able to calculate the total amount of natural gas injected into storage, on average, for the 5-years, and turn that total into an average weekly volume needed to be injected this summer. By estimating the gas volume injections needed this summer, we find a significant hurdle may exist.

Exhibit 20. Heroic Effort To Rebuild Gas Storage

	2010-2014	2011-2015	2012-2016	2013-2017	2018
1-Apr	1,650	1,606	1,798	1,701	1,354
31-Oct	3,782	3,727	3,816	3,781	3,777
Injected	2,132	2,121	2,018	2,080	2,423
Wk Avg.	69	70	68	69	81

Source: EIA, PPHB

The average weekly injection for the prior periods was 68-70 Bcf. To return to a gas storage volume equal to the end of injection season range of the four earlier 5-year averages, gas injections will need to be 13.6% to 20.0% greater than in the past. This translates

into a weekly average gas storage injection volume of 81 Bcf. That means that each week, the industry must inject the equivalent of roughly one day's worth of total national gas output, assuming no production growth during the balance of 2018.

A shortfall in gas storage going into next winter could lead to higher gas prices during next winter

Put in a different context, if we are only able to average 69 Bcf per week of gas injection during the upcoming injection season, then we will wind up with roughly 3,424 Bcf, or about 300 Bcf less than what we have had at the start of past withdrawal seasons. Will the gas industry be able to accomplish this task? If it can't, then there will be upward pressure on gas prices to attempt to stimulate more output, but which might prove futile due to pipeline capacity issues. A shortfall in gas storage going into next winter could lead to higher gas prices during next winter. An even greater storage shortage heading into the 2019 injection season would certainly lead to higher gas prices this winter and next year.

The analysis projects an increase in gas demand next winter of 4.0-4.5 Bcf/d from industrial, power burn and LNG shipments, meaning that surplus supply will average 2.5-3.0 Bcf/d for winter's 23 weeks

An analysis from HFIR Energy suggested that despite the fact that the industry may wind up with about 800 Bcf less storage at the end of April than in 2017, this will not create a supply shortage. They see gas storage at the start of the withdrawal season at 3,650 Bcf, with a range of 3,400-3,900 Bcf. They pointed to the 2,441 Bcf of gas withdrawn from storage this winter, at a time when the nation averaged gas production of about 77.2 Bcf/d. They see current production at 80 Bcf/d, and heading to 83 Bcf/d by year end. They further estimate that gas production will average 84.5 Bcf/d during the winter of 2018-2019, which is 7 Bcf/d more than last winter. The analysis projects an increase in gas demand next winter of 4.0-4.5 Bcf/d from industrial, power burn and LNG shipments, meaning that surplus supply will average 2.5-3.0 Bcf/d for winter's 23 weeks. That means an additional 644 Bcf of supply to meet winter demand.

That outcome suggests to HFIR Energy that there is no reason for natural gas prices to increase from current levels by next summer

The analysis goes on to suggest that the average winter withdrawal for the last five years was 2,119 Bcf, but this past winter was colder, thus the greater withdrawal. Assuming similar winter weather next year, then only 1,797 Bcf of gas needs to be withdrawn from storage. When they subtract this net demand from the 3,650 Bcf storage target, or the 3,400 Bcf low estimate, they arrive at remaining storage volumes of 1,603-1,853 Bcf, which is roughly 300-500 Bcf more supply than currently in storage. That outcome suggests to HFIR Energy that there is no reason for natural gas prices to increase from current levels by next summer.

With all the attention on oil prices, failure to pay attention to the natural gas market could be a mistake

The health of the natural gas market this summer may prove crucial for not only gas prices, but also utility rates, LNG exports, oilfield service activity and gas producers' financial health. With all the attention on oil prices, failure to pay attention to the natural gas market could be a mistake. However, as we said in the last *Musings when* we last wrote about the gas market: "Many questions. Few answers. Plenty to watch." That sentiment hasn't changed.

StormGeo And Others Issue Early Hurricane Forecasts

We recently attended a luncheon hosted by the StormGeo team in Houston to introduce clients and potential clients to the firm's newly enhanced services for tracking and forecasting severe weather events. The lunch presentation included a review of the 2017 hurricane season, with particular attention on the three major storms – Harvey (CAT 4), Irma (CAT 5) and Maria (CAT 5) – that devastated three different areas of the United States. It also included introducing the firm's 2018 hurricane forecast, as well as discussing how StormGeo can help firms deal with disrupting weather events.

The audience clearly identified with the devastation delivered to the Texas Gulf Coast

As the lunch presentation was being held in Houston, the audience clearly identified with the devastation delivered to the Texas Gulf Coast and the cities of Corpus Christi, Houston, Baytown and Beaumont by Harvey last August. The lunch meeting happened on the day following the two-day celebration of the Houston Astros World Series victory, which was closely associated with the Houston Strong rallying cry after Harvey's flood waters receded.

There were many wonderful stories told about TCH's experience

Management's presentation of its suite of products and services for storm monitoring offered teasers about ones under development. This presentation included a discussion by the business continuity executive for Texas Children's Hospital system, which focused on how it worked with StormGeo to prepare and manage through Hurricane Harvey. There were many wonderful stories told about TCH's experience, so we have to believe any clients possibly considering teaming up with StormGeo had to be impressed.

A number of years ago we had discovered a meteorological team at ImpactWeather, Inc., a division of Universal Weather and Aviation, Inc. We found their hurricane work to be highly sophisticated and well presented. We had previously identified other hurricane experts – the late Professor William Gray and his associate, Phil Klotzbach, and Joe Bastardi – who we relied on for our articles about hurricanes. ImpactWeather's team became our third trusted source.

The firm's focus is on communicating the impact of weather on businesses

In May 2011, StormGeo purchased ImpactWeather. The move created a global meteorological and weather forecasting firm that now employs 400 staff, mostly professionals, and operates from 22 offices in 16 countries, with headquarters in Bergen, Norway. The firm's focus is on communicating the impact of weather on businesses, with a concentration on a handful of industries including shipping, oil and gas, marine operations, renewables, aviation, cross industry and media. With the firm's scale and span, it is able to provide forecasts and tracking of weather events 24/7. But, possibly the greatest benefit of the firm's increased scale is its ability to spend increased amounts on research and development of forecasting techniques, data gathering and improved customer assistance, including helping develop crisis preparation plans.

His research contributed to the early equations that are used to build climate models

It was only recently that we learned about the history of StormGeo. Bergen is the birthplace of modern weather forecasting. The city is situated in the midst of seven mountains on the coast of the North Sea, which made it a center for maritime industries in Norway. It is also an important port for the North Sea oil and gas industry. Bergen's location also meant it experiences very rainy weather, which contributed to the historical fascination of its people with weather research. Until Norwegian physicist Vilhelm Bjerknes introduced mathematics and physics into meteorology, weather forecasts were very short term and unreliable since they were usually based on past experiences and scattered weather observations. His research contributed to the early equations that are used to build climate models. His research focused on the fundamental interaction between fluid dynamics and thermodynamics and contributed to better understanding of the large-scale motions of the oceans and atmosphere, leading to the foundation of modern weather forecasting.

Mr. Bjerknes founded the Bergen School of Meteorology and the Geophysical Institute at the University of Bergen. Many of StormGeo's scientists were trained at these institutions. The Bergen School introduced the new concepts of weather fronts and air masses, which contributed to defining the motion of the atmosphere through mathematical relationships.

Today, StormGeo is providing its clients storm forecasts beginning seven days ahead, in contrast to the five-day forecasts provided by the National Weather Service

StormGeo was founded in 1997 as Storm Weather Center, a spin-off from TV2, the largest commercial broadcaster in Norway, headquartered in Bergen. TV2 pioneered weather reporting by showing the first animated fronts and pressure systems. As viewers were captivated by the imagery, forecasts improved, and many people beyond the maritime and oil and gas businesses found value in their use. As the techniques for studying, tracking and forecasting storms improved, StormGeo has continued to invest heavily in new research and development of the science. Today, StormGeo is providing its clients storm forecasts beginning seven days ahead, in contrast to the five-day forecasts provided by the National Weather Service. That earlier warning enables clients to target the potential impact on their installations and better prepare.

The StormGeo forecast for the upcoming hurricane season is consistent with others relative to the climate conditions impacting the storm season and where storms are most likely to be concentrated. As we wrote in our last *Musings* (April 3, 2018), WeatherBELL issued an early tropical storm forecast calling for 11-15 named storms, 5-7 becoming hurricanes and 1-3 achieving major storm intensity (CAT 3 or greater) of 111 miles per hour winds or greater during a storm's existence.

About the same time StormGeo was speaking, the Tropical Meteorological Project of the Colorado State University Department of Atmospheric Science (CSU) issued its early prediction for the

2018 storm season. We have captured the details of all three forecasts in Exhibit 21. The ACE measure (accumulated cyclone energy) is a measure of a named storm's potential for wind and storm surge destruction. It is a mathematical calculation involving a storm's maximum wind speed for each 6-hour period of its existence. Importantly, the 1950-2000 average ACE value for the Atlantic basin is 96. Therefore, if forecasts call for more or less than the average ACE, it is an indication of the degree of activity and intensity expected for the storm season.

Exhibit 21. Early 2018 Hurricane Forecasts

Category	WeatherBELL	CSU	StormGeo
Named Storms	11-15	14	13
Hurricanes	5-7	7	7
CAT 3 or greater	1-3	3	4
ACE	90-110	130	120

Source: WeatherBELL, CSU, StormGeo, PPHB

Everyone sees warm sea surface temperatures (SST) in the South Pacific as key

The forecast similarities are tied to the underlying climate conditions currently existing and the expectations for how they might change as the storm season, which lasts from June 1 to November 30, unfolds. While everyone sees warm sea surface temperatures (SST) in the South Pacific as key, the cooler waters in the northeast Atlantic and along the U.S. East Coast and off the west coast of Africa (the spawning grounds for tropical storms) may keep the season from being more active than predicted.

We laughed when we saw various media stories about the CSU forecast due to their headlines. For example, *Time* magazine headlined its story with "Forecasters Are Warning This Year's Hurricane Season Will Be Worse Than Usual." Note the use of the word "will," which implies a guarantee. On the other hand, the environmental writer for *The Houston Chronicle* had this headline on her story: "The 2018 hurricane season will not be as bad as last year, forecasters predict."

Their key message was: "Coastal residents are reminded that it only takes one hurricane making landfall to make it an active season for them, and they need to prepare the same for every season, regardless of how much activity is predicted"

The most accurate statement to come from the interpretations of the forecast data was written by the CSU team in its report. They characterized their forecast this way: "the 2018 Atlantic hurricane season will have activity slightly above the median 1981-2010 season." However, their key message was: "Coastal residents are reminded that it only takes one hurricane making landfall to make it an active season for them, and they need to prepare the same for every season, regardless of how much activity is predicted." This is the message that every forecaster wants his readers to carry away – it's not just how active the hurricane season may be, if one arrives at your doorstop, you need to be prepared, and, no matter how many storms occur during the season, you will consider it to have been an active storm season.

SST in the Pacific show very warm conditions

The CSU report had some interesting charts that show the climatology now, which is shaping the forecasts. SST in the Pacific show very warm conditions, as can be seen in the yellow and orange areas. Much of the blue area is barely below neutral temperature variations.

Exhibit 22. Warm Sea Surface Temperatures In Pacific

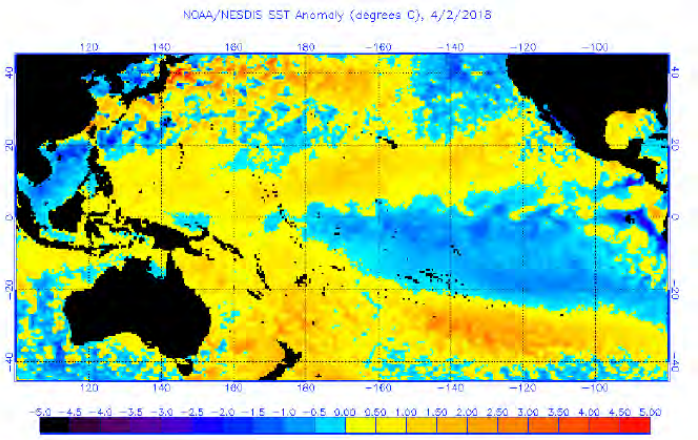


Figure 10: Current SST anomalies across the tropical and subtropical Pacific.
Source: NOAA

In the Atlantic basin, water conditions are quite different, and confusing for many forecasters

In the Atlantic basin, water conditions are quite different, and confusing for many forecasters. That is due to the uncertainty of what these conditions will be like during the peak of the season this summer. As of now, as shown in Exhibit 23, the North Atlantic is

Exhibit 23. Sea Surface Temperatures In Atlantic Basin

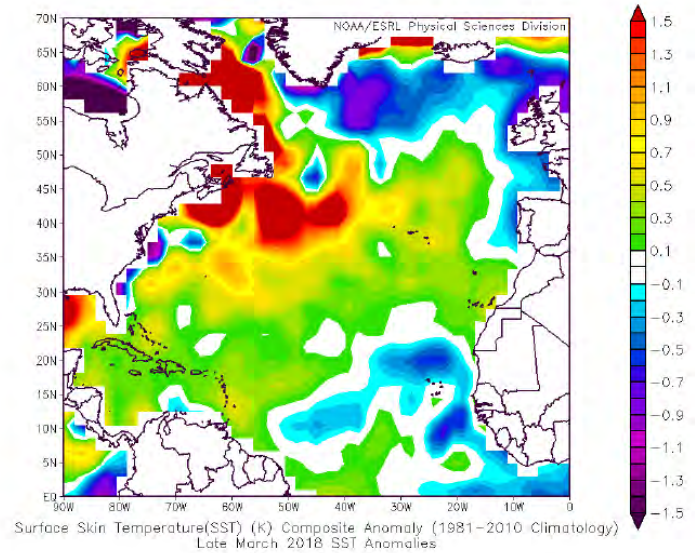


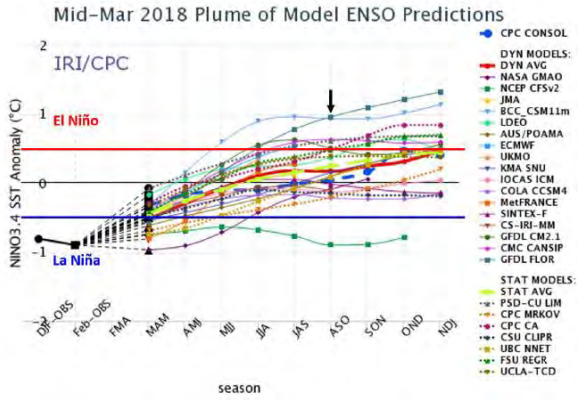
Figure 16: Late March 2018 SST anomaly pattern across the Atlantic Ocean.
Source: NOAA

extremely cold, while off West Africa and along the U.S. East Coast water temperatures are cool. Will those conditions exist this summer? If so, it could temper storm formation due to the creation of wind shear that impedes storm formation and intensification.

The uncertainty of whether there will be an El Niño this summer

What appears to be a major debating point among forecasters, and something that the StormGeo people spent considerable time explaining, is the uncertainty of whether there will be an El Niño this summer. Some forecasters expect a weak one, but others don't think one will form. Helping confuse the issue is the various climate computer models for the balance of the year. As shown in Exhibit 24, about a third of them are calling for El Niño conditions by September, the height of the hurricane season.

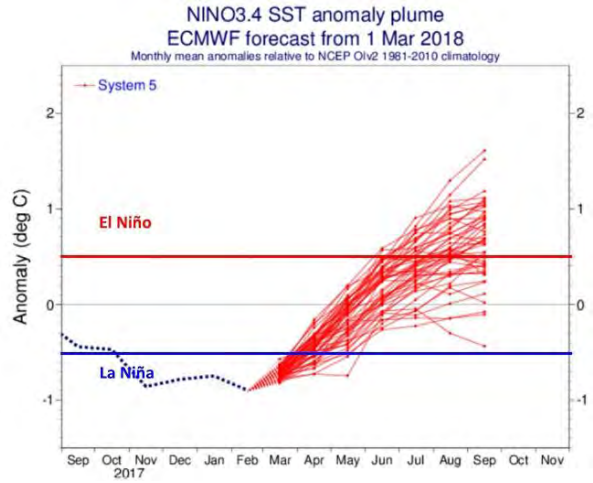
Exhibit 24. El Niño Predictions For Summer



Source: CSU

The overall expectation for El Niño conditions is influenced by the bias of the European climate models that show over half predicting such an event by September. Observations by some weather

Exhibit 25. European Models Favor El Niño



Source: CSU

forecasters about this bias makes them skeptical of what may happen this summer. In other words, uncertainty rules, so stay tuned.

We were struck by the similarities and differences in the selection of the analog years

After studying the three hurricane forecasts, we were struck by the similarities and differences in the selection of the analog years used to modify the statistical output from each firm's forecast model. We have listed all the analog years used by each forecaster to see how they compare.

Exhibit 26. The Portfolio Of Analog Years

Analog Years For Storm Forecasts		
WeatherBELL	CSU	StormGeo
1934	1960	1960
1951	1967	1966
1996	1996	1968
2006	2006	1976
2011	2011	1992
2014		1993

Source: WeatherBELL, CSU, StormGeo, PPHB

What we see in the analog year comparison is greater similarity between WeatherBELL and CSU. On the other hand, StormGeo only has one similar year with CSU and none with WeatherBELL. StormGeo does use two years (1966 and 1968) that bracket CSU's selection of 1967. Even more interesting was seeing WeatherBELL double-weighting their 1951 and 1960 selections, and then adding 2014, which they characterized as having SSTs that are the closest match with current conditions.

A judgement call on climate conditions

All of this goes to demonstrate how much hurricane forecasting remains a judgement call on climate conditions and the forces that shape and modify them. Some would call that "art."

If it shifts further toward the East Coast, that increases the chance for a Gulf Coast landing, while if it shifts westward, then the East Coast becomes an increased target

We were also drawn to the conclusion CSU made about the high likelihood of major hurricanes making landfall along the U.S. coastline. They see a 63% probability of one striking the U.S. coast versus a 52% probability for the past century. For the length of the U.S. East Coast, the probability is 39% (31%), while the Gulf Coast's is 38% (30%). StormGeo and WeatherBELL had similar conclusions, although not presented with quite as much specificity. As StormGeo pointed out in its presentation, the determining factor will be where in the Southeast region of the United States the main low-pressure center sits during the hurricane season. If it shifts further toward the East Coast, that increases the chance for a Gulf Coast landing, while if it shifts westward, then the East Coast becomes an increased target.

We remain fascinated with long-range weather forecasting, and hurricane predictions, as these storms impact energy in one way or another. We will be monitoring the forecasting revisions as we head into the hurricane season in about six weeks.

Will Kinder Morgan Close Down Canada's Energy Business?

The company would abandon the project if the provincial and federal governments cannot work out an agreement

Sunday, April 8, 2018, may become a monumental date in the history of Canada's energy industry, and the country's standing worldwide. On that day, Kinder Morgan Canada Ltd. (KML-TSX), a subsidiary of its U.S. parent, issued a press release stating it had suspended all "non-essential activities and related spending" on the expansion of its Trans Mountain pipeline. The press release went on to say that the company would abandon the project if the provincial and federal governments cannot work out an agreement to allow the legally-approved and compliant project to move forward.

The 500,000 barrels a day pipeline expansion has been the subject of extensive political and legal tussles between the British Columbia government and its residents and those of Alberta and the federal government. While this pipeline battle has the potential for derailing the significant expansion of Canada's oil export capacity, it may do greater damage to the political standing of Canada as a stable location for the development of long-term energy projects.

Estimates are that it costs C$15 (US$12) per barrel to ship by rail versus half that amount by pipeline

For Canadian oil producers faced with the prospect of a lack of a meaningful increase in the cheapest export system, their alternative is to increase the volume of oil they ship by rail. Unfortunately, that export option is more expensive. Estimates are that it costs C$15 (US$12) per barrel to ship by rail versus half that amount by pipeline. With the current wide negative price differential for oil coming from the Western Canadian Sedimentary Basin, this high cost transportation option could be the difference in whether new oil projects/wells go ahead. Even if production grows, export volume increases will be limited by the availability of rail cars and transportation routes.

It has the support of all governments involved in approving the project

Kinder Morgan's announcement demanding political and legal obstacle resolution comes after it has won every legal challenge. In addition, it has the support of all governments involved in approving the project, although BC's approval came from the province's prior government, which was displaced in the last election by politicians dedicated to fighting new and expanding energy projects.

The roster of abandoned Canadian energy projects will grow if the C$7.4 (US$5.9) billion Trans Mountain's expansion is cancelled. It would join Enbridge's (ENB-NYSE) cancelled C$7.9 (US$6.3) billion Northern Gateway pipeline, Petronas' (PNAGF-Nasdaq) C$36 (US$28.6) billion Pacific Northwest LNG project and TransCanada's (TRP-NYSE) C$12 (US$9.5) billion Energy East pipeline proposal.

For an industry that operates with decades-long planning and development timetables, this hostile attitude could cause long-term damage for Canada's economy

For the federal government, its support of certain energy projects, while fighting others, has allowed itself to be positioned as both pro-energy and anti-energy. This split political personality is seen by the global energy industry as a sign Canada has evolved into a hostile location to do business. For an industry that operates with decades-long planning and development timetables, this hostile attitude could cause long-term damage for Canada's economy, and especially its western provinces where the energy industry is centered. Energy hostility will also put the mining, timber and other extractive industries on notice that their growth may soon become challenged.

Alberta's premier has indicated her support for the province to purchase the Trans Mountain project to ensure it is constructed

This is not a pretty outlook for Canadians, but we would hasten to add that many of them live in the liberal coastal regions of the nation and are oblivious to the financial and economic benefits of the oil and gas industry on Canada's wellbeing. That is a reason why Alberta's premier has indicated her support for the province to purchase the Trans Mountain project to ensure it is constructed. Even Canada's Energy Minister has indicated his support for the federal government to invest in the project to ensure its construction. We are not sure what these moves will do for the project that a profit-oriented owner, operating with the legal support of the courts, can't achieve. We take the premier's and federal minister's claims as their way of highlighting the critical importance of this project to the health of their respective constituents' finances. Stay tuned, as the fate of Canada's economy and the future of its oil and gas industry may be determined by the end of May.

Is Climate Change In Danger Of Becoming Irrelevant?

It has the potential for changing the paradigm underlying climate science

A new study published in the journal *Science* shows that there are vast storehouses of nitrogen in the planet's bedrock that is tapped by plants and trees, besides the nitrogen in the atmosphere that they use for photosynthesis. This is a significant development, as it has the potential for changing the paradigm underlying climate science. Such a change will not come easily or swiftly, but this news will reshape the climate change debate.

The volume of CO2 that can be removed from the atmosphere will be much greater than currently assumed in climate models

Climate scientists know that plants offset some of the effects of climate change by absorbing and storing carbon dioxide. Scientists assume that the limited supply of nitrogen in the atmosphere limits the amount of CO_2 that can be offset by plant life. If, as this new study demonstrates, there is a greater supply of nitrogen available for plants, then the volume of CO_2 that can be removed from the atmosphere will be much greater than currently assumed in climate models with their projected disastrous outcomes.

The scientists responsible for this study have been working on demonstrating the existence of this new nitrogen supply source since 2011. This peer-reviewed report has the potential for forcing a change in the paradigm underlying climate science and, importantly, climate modeling. Maybe the planet's cataclysmic future shaped by

burning more fossil fuels and releasing additional CO_2 is not what our future will really be.

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